

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. *(Previously Presented)* An apparatus for sending a heartbeat signal in a cluster computing system, the apparatus comprising:
 - a first host group; and
 - a first storage system comprising a first heartbeat storage volume and a first data storage volume, the first storage system being associated with the first host group, the first host group coupled via a network to a second host group, the first storage system coupled via a remote link separate from the network to a second storage system comprising a second heartbeat storage volume and a second data storage volume, the second storage system being associated with the second host group, the first host group configured to selectively send a heartbeat signal to the second host group by use of the remote link by sending a memory command to the first heartbeat storage volume of the first storage system which is mirrored via the remote link using a remote copy mechanism to the second heartbeat storage volume of the second storage system, wherein the second host group is configured to use the received heartbeat signal to determine whether a failover should be performed; and wherein:
 - the first heartbeat storage volume and the second heartbeat storage volume form a remote mirror being in an enabled mode;
 - the first heartbeat storage volume is registered to a device address entry;

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

the first host group operable to send an activation message to the second host group; and the second heartbeat volume is registered to the device address entry.

2. *(Previously Presented)* A method of sending a heartbeat signal in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a first host group in a production site, the first host group being associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:
registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;
registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second host group by use of the remote mirror formed by the first heartbeat storage volume and the second heartbeat storage volume, the heartbeat signal being sent from the first heartbeat storage volume of the first storage system via the remote link to the second heartbeat storage volume of the

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

second storage system using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failover should be performed.

3. *(Previously Presented)* An electronically-readable medium storing a program for permitting a computer to perform method of sending a heartbeat signal in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a first host group in a production site, the first host group being associated with a first storage system comprising a first heartbeat storage

volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:

registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;

registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and

from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second host group by use of the remote mirror formed by the first heartbeat storage volume and the second heartbeat storage volume, the heartbeat signal being sent from the first heartbeat storage volume of the first storage system via the remote link to the second heartbeat storage volume of the

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

second storage system using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failover should be performed.

4. *(Currently Amended)* A program code stored embedded on an electronically-readable a computer readable medium for causing a computer to perform a method of sending a heartbeat signal in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a first host group in a production site, the first host group being associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:
registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;
registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second host group by use of the remote mirror formed by the first heartbeat storage volume and the second heartbeat storage volume, the heartbeat signal being sent from the first heartbeat storage volume

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

of the first storage system via the remote link to the second heartbeat storage volume of the second storage system using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failover should be performed.

5.-9. (*Cancelled*)

10. (*Previously Presented*) A method of checking for failure in a cluster computing system, the method comprising:

a. generating a heartbeat signal from a first host group in a production site associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;

b. installing remote mirrors in the cluster computing system, including:
registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;

sending an activation message from the production site to a standby site;
registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;

c. selectively sending the heartbeat signal from the first host group to a second host group by use of the remote mirror formed by the first heartbeat storage volume and the

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

second heartbeat storage volume, the heartbeat signal being sent from the first heartbeat storage volume of the first storage system via the remote mirror to the second heartbeat storage volume of the second storage system using a remote copy mechanism, wherein the second host group uses the received heartbeat signal to determine whether a failure has occurred.

11. *(Previously Presented)* A cluster computing system, comprising:
 - a production host group associated with a production storage system comprising a production site heartbeat storage volume (heartbeat PVOL) and a production site data storage volume;
 - a standby host group coupled to the production host group by a network and associated with a standby storage system comprising a standby site heartbeat storage volume (heartbeat SVOL) and a standby site data storage volume; and
 - a remote mirror coupled between the production host group and the standby host group, the remote mirror including the heartbeat PVOL and the heartbeat SVOL coupled by a remote link to the heartbeat PVOL, the remote mirror being separate from the network;
 - the production host group configured to selectively send a heartbeat signal to the standby host group by use of the remote link using a remote copy mechanism, wherein the standby host group uses the received heartbeat signal to determine whether a failover should be performed and wherein:
 - the remote mirror being in an enabled mode;
 - the heartbeat PVOL is registered to a device address entry;

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

the production host group is operable to send an activation message to the standby host group; and

the heartbeat SVOL is registered to the device address entry.

12. *(Original)* The cluster computing system of claim 11 wherein the production host group comprises a first heartbeat check module configured to generate the heartbeat signal.

13. *(Original)* The cluster computing system of claim 11 wherein the standby host group comprises a second heartbeat check module configured to receive the heartbeat signal.

14. *(Original)* The cluster computing system of claim 11 wherein the standby host group manages operations of the cluster computing system if an invalid heartbeat signal is received by the standby host group from the production host group.

15. *(Original)* The cluster computing system of claim 11 wherein the heartbeat message comprises: a serial number assigned to the heartbeat message, a time indicator indicating a time of the generation of the heartbeat message, and an identifier identifying a sender of the heartbeat message.

16. *(Previously Presented)* The cluster computing system of claim 11 further comprising:

a second remote mirror coupled between the production host group and the standby host group, the second remote mirror including a second remote link for transmitting a heartbeat signal;

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

the standby host group configured to selectively send a heartbeat signal to the production host group by use of the second remote link.

17. (*Previously Presented*) A method of checking for failure in a cluster computing system, the method comprising:

- a. generating a heartbeat signal from a production host group in a production site associated with a first storage system comprising a first heartbeat storage volume and a first data storage volume;
- b. installing remote mirrors in the cluster computing system, including:
 - registering the first heartbeat storage volume to a device address entry, and, from the production site, changing a remote mirror that includes the first heartbeat storage volume into an enabled mode;
 - sending an activation message from the production site to a standby site;
 - registering a second heartbeat storage volume of a second storage system to the device address entry, the second heartbeat storage volume located in the standby site; and
 - from the standby site, changing the remote mirror into an enabled mode to install a remote mirror formed by the first heartbeat storage volume and second heartbeat storage volume;
- c. selectively sending the heartbeat signal to a standby host group in the standby site from the production host group in the production site by use of the remote mirror formed by the first heartbeat storage volume and the second heartbeat storage volume using a remote copy mechanism;

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

- d. determining, by the standby host group, that a failure has occurred, if an invalid heartbeat signal is received by the standby host group from the production host group; and
- e. enabling the standby host group to manage operations of the cluster computing system if the failure has occurred.

18. (*Previously Presented*) The method of claim 17 further comprising:
selectively sending a heartbeat signal to the production host group from the standby host group by use of a second remote link.

19. (*Cancelled*)

20. (*Original*) The method of claim 17 further comprising:
de-installing remote mirrors in the cluster computing system, including:
from a production site, changing a remote mirror into a disabled mode;
sending a de-activation message from the first production site to a standby site; and
from the standby site, changing the remote mirror into a disabled mode to de-install the
remote mirror.

21. (*Original*) The method of claim 17 wherein the selectively sending step
comprises:

determining if a network between the production site host and the standby site host is
enabled;
if the network is enabled, sending a heartbeat message along the network from the
production site host to the standby site host;

AMENDMENT UNDER 37 C.F.R. §1.312
U.S. Application No. 09/760,345

determining if a remote mirror between the production site host and the standby site host is enabled; and

if the remote mirror is enabled, sending a heartbeat message along the remote mirror from the production site host to the standby site host.

22. (*Original*) The method of claim 17 further comprising:

receiving a heartbeat message from the production site host to the standby site host in the cluster computing system, including:

determining if a network between the production site host and the standby site host is enabled;

if the network is enabled, checking for a heartbeat message along the network from the production site host to the standby site host;

determining if a remote mirror between the production site host and the standby site host is enabled;

if the remote mirror is enabled, checking for a heartbeat message along the remote mirror from the production site host to the standby site host; and if an invalid heartbeat is received along the network and along the remote mirror, enabling the standby host to manage operations of the cluster computing system.

23-24. (*Canceled*)